A Framework for Robust Multivariable Optimization of Integrated Circuits in Space Applications

Jeffrey DuMonthier and George Suarez
NASA Goddard Space Flight Center
8800 Greenbelt Road
Greenbelt, MD 20771
{Jeffrey.J.DuMonthier, George.Suarez}@nasa.gov

***Abstract*—Application Specific Integrated Circuit (ASIC) design for space applications involves multiple challenges of maximizing performance, minimizing power and ensuring reliable operation in extreme environments. This is a complex multi-dimensional optimization problem which must be solved early in the development cycle of a system due to the time required for testing and qualification severely limiting opportunities to modify and iterate. Manual design techniques which generally involve simulation at one or a small number of corners with a very limited set of simultaneously variable parameters in order to make the problem tractable are inefficient and not guaranteed to achieve the best possible results within the performance envelope defined by the process and environmental requirements. What is required is a means to automate design parameter variation, allow the designer to specify operational constraints and performance goals, and to analyze the results in a way which facilitates identifying the tradeoffs defining the performance envelope over the full set of process and environmental corner cases.**

The system developed by the Mixed Signal ASIC Group (MSAG) at the Goddard Space Flight Center is implemented as framework of software modules, templates and function libraries. It integrates CAD tools and a mathematical computing environment, and can be customized for new circuit designs with only a modest amount of effort as most common tasks are already encapsulated. Customization is required for simulation test benches to determine performance metrics and for cost function computation. Templates provide a starting point for both while toolbox functions minimize the code required. Once a test bench has been coded to optimize a particular circuit, it is also used to verify the final design. The combination of test bench and cost function can then serve as a template for similar circuits or be re-used to migrate the design to different processes by re-running it with the new process specific device models. The system has been used in the design of time to digital converters for laser ranging and time-of-flight mass spectrometry to optimize analog, mixed signal and digital circuits such as charge sensitive amplifiers, comparators, delay elements, radiation tolerant dual interlocked (DICE) flip-flops and two of three voter gates.

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